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Byrd, E

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WHAT IS CLAIMED IS:

1. A receiver for receiving complex symbols in a radio¹ communication system, comprising:
 - 2
 - 5 a symbol arranger for collecting signals from at least one receiver³ antenna over four time intervals, the at least one receiver antenna receiving the⁴ signals from at least three transmitter antennas; ⁵
 - a channel estimator for estimating at least three channel gains from the at ⁶ least three transmitter antennas to the at least one receiver antenna; ⁷
 - 10 a first decoder for computing metrics for all possible pairs of symbols⁸ using the received signals and the channel gains, and for detecting two symbols⁹ giving a minimum metric; ¹⁰
 - a second decoder for computing metrics for all possible pairs of symbols¹¹ using the received signals and the channel gains, and for detecting two symbols¹²
 - 15 giving a minimum metric; and ¹³
 - a parallel-to-serial converter for arranging the four symbols detected by¹⁴ the first and second decoders in the right order, ¹⁵
 - wherein the first and second decoders each linearly operate the received signals with the channel gains, pre-detect two symbols using threshold detection,
 - 20 and output the pre-detected two symbols as final symbols if the product of the product of the pre-detected symbols and a constant determined by the channel gains is a minimum.
2. The receiver of claim 1, wherein the number of the transmitter²⁵ antennas is 3.
3. The receiver of claim 2, wherein the first and second decoders each pre-detect two symbols s_1 and s_3 or s_2 and s_4 , respectively, that minimize $|R_1 - e^{j\theta_1}s_1|^2 + |R_3 - s_3|^2$ or $|R_2 - s_2|^2 + |R_4 - e^{j\theta_4}s_4|^2$, respectively, where θ_1 and θ_4

are phase rotation values used in a transmitter,

$$R_1 = r_1 h_1^* + r_2^* h_2 + r_3^* h_3, \quad R_3 = r_2^* h_3 + r_4 h_1^* + -r_3^* h_2,$$

$$R_2 = r_1 h_2^* - r_2^* h_1 + r_4 h_3^*, \quad R_4 = r_1 h_3^* - r_3^* h_1 - r_4 h_2^*,$$

r_1, r_2, r_3 and r_4 are the signals received over the four time intervals, and h_1, h_2 , and
5 h_3 are the channel gains of the three antennas.

4. The receiver of claim 3, wherein the first and second decoders output the pre-detected symbols as final symbols if $(C_3) \text{Re}\{e^{-j\theta_1} s_1^* s_3\}$ or $(-C_3) \text{Re}\{s_2^* e^{j\theta_4} s_4\}$ is a minimum, where $C_3 = h_3 h_2^* - h_3^* h_2$ and h_2 and h_3 are the
10 channel gains of two of the three transmitter antennas.

5. The receiver of claim 4, wherein the first and second decoders detect two symbols s_1 and s_3 or s_2 and s_4 , respectively, that minimize

$$\begin{aligned} & |R_1 - e^{j\theta_1} s_1|^2 + |R_3 - s_3|^2 + 2(C_3) \text{Re}\{e^{-j\theta_1} s_1^* s_3\} \text{ or} \\ 15 \quad & |R_2 - s_2|^2 + |R_4 - s^{j\theta_4} s_4|^2 + 2(-C_3) \text{Re}\{s_2^* e^{j\theta_4} s_4\}, \end{aligned}$$

respectively, if $(C_3) \text{Re}\{e^{-j\theta_1} s_1^* s_3\}$ or $(-C_3) \text{Re}\{s_2^* e^{j\theta_4} s_4\}$ is not a minimum.

6. The receiver of claim 1, wherein the number of the transmitter antennas is 4.

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7. The receiver of claim 6, wherein the first and second decoders each pre-detect two symbols s_1 and s_3 or s_2 and s_4 , respectively, that minimize

$$|R_1 - e^{j\theta_1} s_1|^2 + |R_3 - s_3|^2 \text{ or } |R_2 - s_2|^2 + |R_4 - e^{j\theta_4} s_4|^2, \text{ respectively, in which } \theta_1 \text{ and } \theta_4$$

are phase rotation values used in a transmitter, and R_1, R_3, R_2 , and R_4 are defined

25 as

$$R_1 = \frac{(r_1 h_1^* + r_2^* h_2 + r_3^* h_3 - r_4 h_4^*)}{K}, R_3 = \frac{(r_1 h_4^* + r_2^* h_3 - r_3^* h_2 + r_4 h_1^*)}{K}$$

$$R_2 = \frac{(r_1 h_2^* - r_2^* h_1 + r_3^* h_4 + r_4 h_3^*)}{K}, R_4 = \frac{(r_1 h_3^* - r_2^* h_4 - r_3^* h_1 - r_4 h_2^*)}{K}$$

$$K = |h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2$$

where r_1, r_2, r_3 and r_4 are the signals received over the four time intervals, and h_1, h_2, h_3 , and h_4 are the channel gains of the four antennas.

- 5 8. The receiver of claim 7, wherein the first and second decoders output the pre-detected symbols as final symbols if $|R_{13} - x_1^* x_3|^2 - |x_1|^2 |x_3|^2$ or $|R_{24} - x_2^* x_4|^2 - |x_2|^2 |x_4|^2$ is a minimum, where R_{13} and R_{24} are defined as

$$R_{13} = \frac{(-h_1 h_4^* + h_1^* h_4 - h_2^* h_3 + h_2 h_3^*)}{K}, R_{24} = \frac{(-h_2 h_3^* - h_1^* h_4 + h_4^* h_1 + h_3 h_2^*)}{K}$$

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9. The receiver of claim 8, wherein the first and second decoders each detect two symbols s_1 and s_3 or s_2 and s_4 , respectively, that minimize

$$|R_1 - x_1|^2 + |R_3 - x_3|^2 + 2(C_3) \text{Re}\{x_1^* x_3\} \text{ or}$$

$$|R_2 - x_2|^2 + |R_4 - x_4|^2 + 2(C_3) \text{Re}\{x_2^* x_4\},$$

- 15 respectively, if $|R_{13} - x_1^* x_3|^2 - |x_1|^2 |x_3|^2$ or $|R_{24} - x_2^* x_4|^2 - |x_2|^2 |x_4|^2$ is not a minimum.

10. The receiver of claim 1, wherein each of the first and second decoders comprises: 2

a symbol generator for generating all possible symbol sub-combinations, 3

- 20 each symbol sub-combination containing two symbols; 4

a phase rotator for rotating the phase of one symbol in each symbol sub-combination by a predetermined value; 5

a threshold detector for linearly operating the received signals with the 6

channel gains and pre-detecting two symbols using threshold detection; 8

a decider for computing that the pre-detected symbols are final symbols 9
if the product of the product of the pre-detected symbols and a constant 10
determined by the channel gains is a minimum; 11

5 a metric calculator for computing the metrics of the symbol sub-12
combinations, each containing a phase-rotated symbol, using the received signals 13
and the channel gains; and 14

a detector for detecting two symbols having a minimum metric using the 15
computed metrics. 16

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11. The receiver of claim 10, wherein the number of the transmitter
antennas is 3.

12. The receiver of claim 11, wherein the threshold detector pre-
15 detects two symbols s_1 and s_3 or s_2 and s_4 that minimize $|R_1 - e^{j\theta_1}s_1|^2 + |R_3 - s_3|^2$ or
 $|R_2 - s_2|^2 + |R_4 - e^{j\theta_4}s_4|^2$ where θ_1 and θ_4 are phase rotation values used in a
transmitter,

$$R_1 = r_1h_1^* + r_2^*h_2 + r_3^*h_3, \quad R_3 = r_2^*h_3 + r_4h_1^* - r_3^*h_2,$$

$$R_2 = r_1h_2^* - r_2^*h_1 + r_4h_3^*, \quad R_4 = r_1h_3^* - r_3^*h_1 - r_4h_2^*,$$

20 r_1, r_2, r_3 and r_4 are the signals received over the four time intervals, and h_1, h_2 , and
 h_3 are the channel gains of the three antennas.

13. The receiver of claim 12, wherein the decider outputs the pre-
detected symbols as final symbols if $(C_3)\text{Re}\{e^{-j\theta_1}s_1^*s_3\}$ or $(-C_3)\text{Re}\{s_2^*e^{j\theta_4}s_4\}$ is a
25 minimum, where $C_3 = h_3h_2^* - h_3^*h_2$ and h_2 and h_3 are the channel gains of two of
the three transmitter antennas.

14. The receiver of claim 13, wherein the metric calculator detects

two symbols s_1 and s_3 or s_2 and s_4 that minimize

$$|R_1 - e^{j\theta_1} s_1|^2 + |R_3 - s_3|^2 + 2(C_3) \operatorname{Re}\{e^{-j\theta_1} s_1^* s_3\} \text{ or}$$

$$|R_2 - s_2|^2 + |R_4 - e^{j\theta_4} s_4|^2 + 2(-C_3) \operatorname{Re}\{s_2^* e^{j\theta_4} s_4\}$$

if $(C_3) \operatorname{Re}\{e^{-j\theta_1} s_1^* s_3\}$ or $(-C_3) \operatorname{Re}\{s_2^* e^{j\theta_4} s_4\}$ is not a minimum.

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15. The receiver of claim 10, wherein the number of the transmitter antennas is 4.

16. The receiver of claim 15, wherein the threshold detector pre-
10 detects two symbols s_1 and s_3 or s_2 and s_4 that minimize $|R_1 - e^{j\theta_1} s_1|^2 + |R_3 - s_3|^2$ or $|R_2 - s_2|^2 + |R_4 - e^{j\theta_4} s_4|^2$, in which θ_1 and θ_4 are phase rotation values used in a transmitter, and R_1 , R_3 , R_2 , and R_4 are defined as

$$R_1 = \frac{(r_1 h_1^* + r_2^* h_2 + r_3^* h_3 - r_4 h_4^*)}{K}, R_3 = \frac{(r_1 h_4^* + r_2^* h_3 - r_3^* h_2 + r_4 h_1^*)}{K}$$

$$R_2 = \frac{(r_1 h_2^* - r_2^* h_1 + r_3^* h_4 + r_4 h_3^*)}{K}, R_4 = \frac{(r_1 h_3^* - r_2^* h_4 - r_3^* h_1 - r_4 h_2^*)}{K}$$

$$K = |h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2$$

15 where r_1 , r_2 , r_3 and r_4 are the signals received over the four time intervals, and h_1 , h_2 , h_3 , and h_4 are the channel gains of the four antennas.

17. The receiver of claim 16, wherein the decider outputs the pre-
detected symbols as final symbols if $|R_{13} - x_1^* x_3|^2 - |x_1|^2 |x_3|^2$ or
20 $|R_{24} - x_2^* x_4|^2 - |x_2|^2 |x_4|^2$ is a minimum, where R_{13} and R_{24} are defined as

$$R_{13} = \frac{(-h_1 h_4^* + h_1^* h_4 - h_2^* h_3 + h_2 h_3^*)}{K}, R_{24} = \frac{(-h_2 h_3^* - h_1^* h_4 + h_1 h_1^* + h_3 h_2^*)}{K}$$

18. The receiver of claim 17, wherein the metric calculator detects two symbols s_1 and s_3 or s_2 and s_4 that minimize

$$|R_1 - x_1|^2 + |R_3 - x_3|^2 + 2(C_3) \operatorname{Re}\{x_1^* x_3\} \text{ or}$$

5 $|R_2 - x_2|^2 + |R_4 - x_4|^2 + 2(C_3) \operatorname{Re}\{x_2^* x_4\}$

if $|R_{13} - x_1^* x_3|^2 - |x_1|^2 |x_3|^2$ or $|R_{24} - x_2^* x_4|^2 - |x_2|^2 |x_4|^2$ is not a minimum.